

## Acoustics of Speech and Hearing

Lecture 1-10  
Spectrography

## Overview

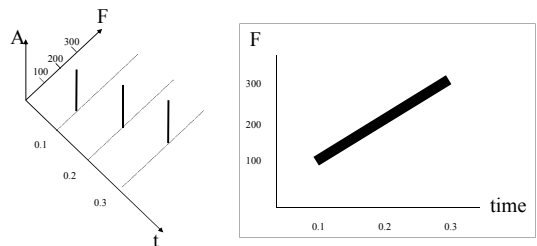
- Spectrograms of simple sounds
- Wide-band vs. Narrow-band spectrograms
- Spectrograms of vowels
- Relationship with filtering

## Spectrogram

- Is a graph of the frequency content of a signal plotted as a function of time
- **Time** is along the horizontal axis
- **Frequency** is along the vertical axis
- **Amplitude** of any component present in the signal at any given time and frequency is displayed on a grey-scale (white=low, black=high)

low  high

## Spectrography



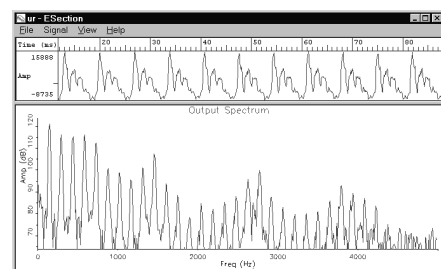
## Spectrograms of simple sounds

- Sinewave
- Complex periodic signal
- Chirp
- Damped sinusoid
- Pulse train
- Pulse train through resonator
- Vowels



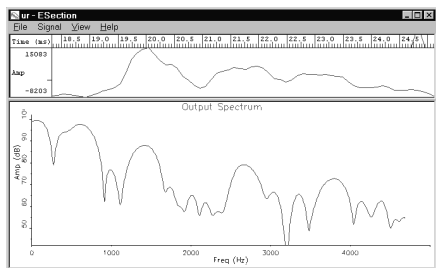
## Reminder

- Spectrum of a Periodic Signal



### Reminder

- Spectrum of an Aperiodic Signal



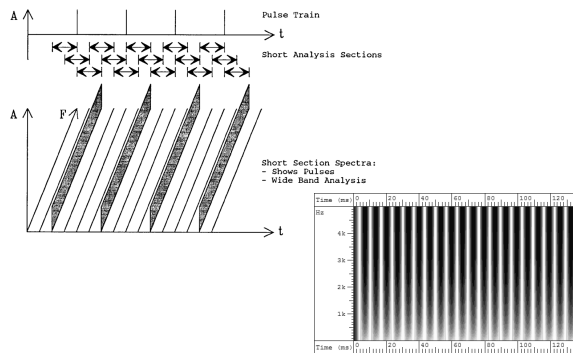
### Reminder

- Analysis of long and short sections of a periodic waveform
  - Long sections:
    - waveform repeats periodically
    - spectrum shows harmonics
  - Short sections:
    - waveform doesn't repeat
    - spectrum is continuous

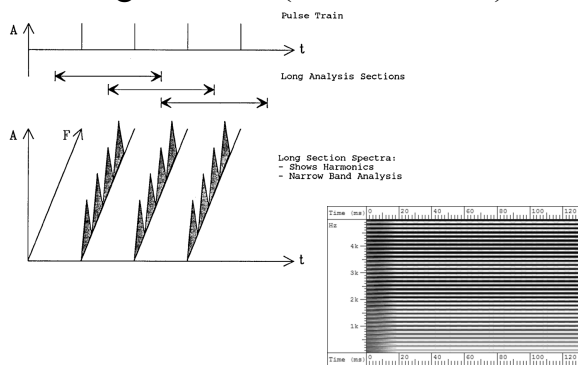
### Two kinds of Spectrogram

- Do we string together spectra calculated from short sections of the signal or from long sections of the signal?
  - Short sections: no harmonics, emphasize temporal changes in signal
  - Long sections: show harmonics, emphasize frequency changes in signal

### Short Sections (Wide Band)

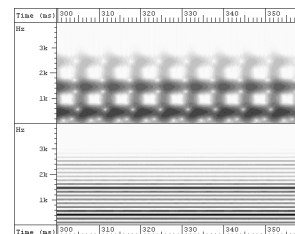


### Long Sections (Narrow Band)

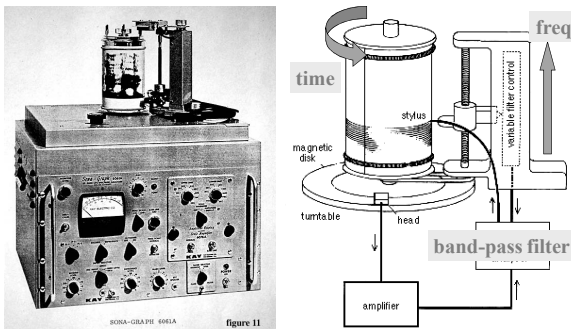


### Wide & Narrow Examples

- Pulse train
  - Steady pitch
  - Changing pitch
- Vowel



### The Sound Spectrograph

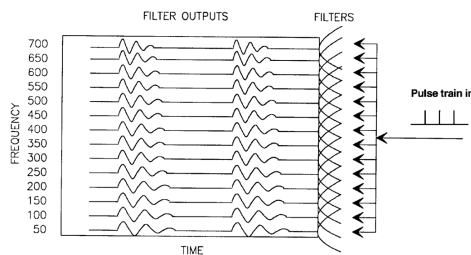


### Relationship with Filtering

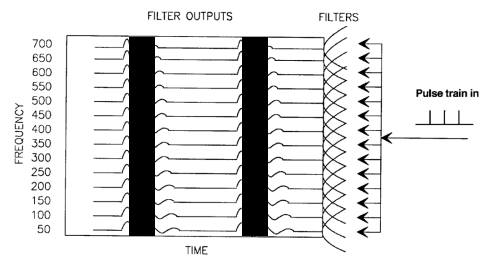
- Wide-band spectrograms
  - Like analysis with wide bandwidth band-pass filters
  - Approx 300Hz wide (equiv to 3ms damping)
  - Wider than any harmonic spacing
  - Each filter “sees” changes within pitch period
- Get spectrogram showing “striations”



### Wide bandwidth filters



### Wide bandwidth filters

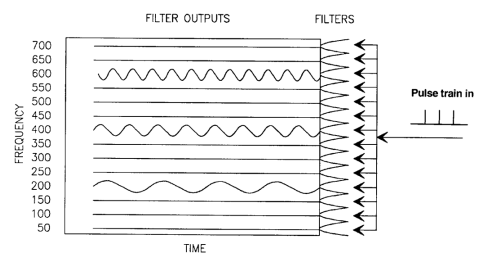


### Relationship with Filtering

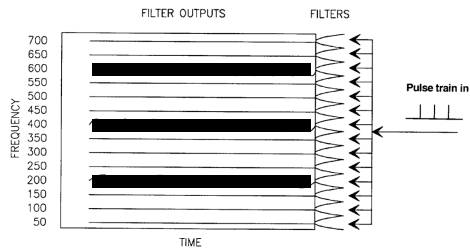
- Narrow-band spectrograms
  - Like analysis with narrow bandwidth band-pass filters
  - Approx 45Hz wide (equiv to 20ms damping)
  - Narrower than any harmonic spacing
  - Each filter “sees” single harmonic or nothing
- Get spectrogram showing harmonics



### Narrow bandwidth filters



### Narrow bandwidth filters



### Wide & Narrow Summary

- Wide-band analysis
  - Short section / Wide filter
  - Good in time resolution
  - Poor in frequency resolution
- Narrow-band analysis
  - Long section / Narrow filter
  - Poor in time resolution
  - Good in frequency resolution

### Summary

- Spectrogram is like a stack of spectrum snapshots
- But get different picture if snapshots are of short or long sections of signal
  - Short sections = “wide band” = fine temporal information
  - Long sections = “narrow band” = fine frequency information

### ASH Term 2

- Larynx Source
  - Voice Quality
  - Intonation
- Vocal Tract Filter
  - Vowels, Fricatives
  - Dynamic sounds
  - Perception
- Hearing
  - Loudness, Pitch & Timbre